Topographic Profiles Across Wrinkle Ridges Indicate Subsurface Faults

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Mars Orbiter Laser Altimeter profiles across wrinkle ridges show characteristic features such as superposed hills, crenulations, and elevation offsets between the plains on either side of the ridge. Previous work has shown that wrinkle ridges result from compressional folding and faulting of near surface units, but the role of thrust faulting and its depth penetration have been argued. The characteristic elevation offsets between plains surfaces on either side of the ridges shown by MOLA are best explained by subsurface thrust faults that underlie the ridges and produce the offset. We examined MOLA elevations where they cross wrinkle ridges in all the characteristic wrinkle ridge provinces on Mars including: Solis Planum. Lunae Planum, Tempe Terra, Xanthe Terra, Arcadia, Terra Sirenum, Thaumasia Planum, Arabia Terra, Syrtis Major, and Hesperia Planum. In most cases the MOLA tracks are nearly parallel to the wrinkle ridges so that cross-sectional profiles cannot be obtained and elevation offsets across ridges are more difficult to assess. In particular areas such as Solis Planum, however, individual MOLA tracks cross regularly spaced wrinkle ridges at a fairly high angle (30-50°). In Solis Dorsa, wrinkle ridges are 10-20 km wide (well resolved by the 300 m spaced MOLA elevations), have a total relief of 80-250 m and have elevation offsets of 60-180 m (well below the $<$10 m uncertainty in the MOLA elevations). In this region there are about 5 north- to northeast-trending ridges spaced about 50 km apart. MOLA tracks show the plains decrease in elevation towards the southeast. Plains surfaces inbetween the ridges are not flat and appear to have been deformed. The elevations of the plains on either side of the ridges are characteristically down to the southeast, suggesting that faults beneath the wrinkle ridges offset the plains. This offset indicates thrust faults that dip to the northwest and systematically lower the southeast side of the plains. The observation that the elevation offsets across the ridges is maintained to the next ridge implies that the thrust fault penetrates to depths of tens of kilometers and thus well into the lithosphere. These observations are not consistent with models for the formation of wrinkle ridges that involve folding of near surface layers only or subsurface thrust faults that flatten into decollements at shallow depths.